THE EFFECT OF MOVEMENTS OF THE HUMAN BODY ON THE SIZE OF THE SPINAL CANAL.

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Our object in making the following short series of experiments has been to test the possibility of an alteration taking place in the capacity of the cerebro-spinal canal during the performance of such movements as can, under ordinary or extraordinary circumstances, occur in the jointed walls of that canal between the bones composing the cranio-vertebra axis. A few preliminary observations fully sufficed to show us that a change of capacity of the canal does actually take place, although only to a slight extent. These detectable but small alterations it seemed highly desirable to measure, and obtain permanent records of. The following plan of experiment was therefore devised and in its ultimate form found successful.

The cadaver, the subject of observation, was suspended from the horizontal arm of a strong vertical stand by means of an iron coronet which encircled the skull and held it by four sharp-pointed thumbscrews, screwed into, but not perforating, the calvaria. An additional precaution against the slipping downward of the cadaver was obtained by inserting into the external auditory meatus the ends of a scissors-shaped clip (B). This clip was attached to a rope running over two pulleys at the top of the vertical support. A horizontal iron bar (C) which could be adjusted at any desired height on the vertical stand was employed to act as a fulcrum against which the body could be bent.

The procedure of experiment was as follows. The scalp over the vertex having been removed, a trepan hole measuring 35 mm. across was made in the highest part of the skull, close to one side of the superior longitudinal sinus. The dura mater was thoroughly removed to an extent corresponding with the trepan hole. We then generally found that the brain was separated from the parietes of the cavity sufficiently to admit the handle of a scalpel between it and the overlying dura mater. Water was then poured into the subdural space sufficient to fill up the trepan hole. The water introduced tended to disappear, often rapidly, sinking in level into the subdural space. Especially was this so with the first few ounces poured in; after a certain amount had been introduced the sinking became less rapid. When the trepan hole was quite filled with water a small glass tube (D) surrounded by an india-rubber ring was inserted with as little delay as possible into the hole, and was arranged to fit into it in a perfectly water-tight fashion. Over the end of the glass tube had been previously drawn a thin membrane which floated on the water filling the subdural space; this membrane was made sufficiently redundant to allow it a considerable range of movement on the water. The glass capsule itself was filled with water and put into communication by flexible water-tight joints, with a length of glass tubing almost horizontally placed (E). The farther end of this tubing was the lower, and was placed on the same level as the trepan hole in the skull. In the figure the inclination of this tube is represented as greater than it really was. Finally, this almost horizontal tube and the connections intervening between it and the vertical glass capsule were all completely filled with water.

Beneath the free end of the tube the scale-pan of a sensitive balance was placed in such a way that it received any drops of fluid ejected from the tube. To the other end of the beam of the balance was attached a thread, which passed vertically downwards, and after running round a light pulley hung, carrying a little weight and armed with a small pen arranged for writing upon the blackened surface of a recording drum. The amount of water received by the scale-pan

was represented by the height of the line marked by the recording pen. The scale-pan naturally underwent movement along the arc of a circle; the intervening pulley round which the thread passed converted the movement of the thread into a rectilinear one; in order, therefore, to estimate the amount of water in the pan the drum had before each set of observations to be experimentally graduated. In each observation the measurement recorded is that of the *maximum* displacement obtained in a series of repetitions of the particular movement.

I. *May* 8, 1889.—Cadaver of male child, æt. four years, weight 24 lbs. 10 oz. Cause of death, diphtheria. Trephined at vertex, to left of median line. Head fixed in the coronet in such a way that no part is higher than the median edge of the trepan-hole.

Body hanging freely from the head:—On raising the trunk by the pelvis, thus taking off the extension of the spinal column due to the weight of the trunk and limbs, 263 cubic millimetres of fluid were ejected into the scale-pan. On raising the trunk by the legs 255 cubic millimetres were ejected. When the body was bent far backwards 1,500 cubic millimetres ejected. When the body was bent far forwards 258 cubic millimetres ejected. When the body was rotated by the shoulders either to left or right 78 cubic millimetres ejected.

II. *October* 30, 1889.—Cadaver of male child, æt. seven years; cause of death diphtheria. Trephined at vertex to right of median line.

Body hanging freely from the head:—Raising the trunk by the pelvis caused the ejection of 450 cubic millimetres; bending the body backwards caused ejection of 530 cubic millimetres; bending the body forwards caused ejection of 215 cubic millimetres: rotation by the shoulders to right or left caused ejection of 180 cubic millimetres.

Body hanging as before but with the cervical spine fixed against bar:—Bending the body backwards caused ejection of 215 cubic millimetres; bending the body forwards caused ejection of 180 cubic millimetres.

III. *February* 14, 1890.—Cadaver of woman, æt. twenty-

eight years; cause of death, pericarditis. Trephined at vertex to right of median line. Weight of cadaver, 7 st. 4 lbs.

Body hanging freely from the head:—Raising the trunk by the pelvis caused the ejection of 98 cubic millimetres; bending backwards the body caused the ejection of 480 cubic millimetres; bending the body forwards caused ejection of 220 cubic millimetres; rotation by the shoulders right or left caused ejection of 110 cubic millimetres.

Body hanging as before but with cervical spine fixed against the bar:—Bending the body backwards caused ejection of 230 cubic millimetres; bending the body forward caused ejection of 200 cubic millimetres; bending the trunk backwards through an angle of 40° against a fulcrum two inches below the inferior angle of the scapula caused an ejection of 2,050 cubic millimetres; bending the trunk forwards through an angle of 45° over the fulcrum at same level as last gave a displacement of 20 cubic millimetres.

IV. *November* 20, 1889.—Cadaver, male, weighing 11st. 4lbs., æt. thirty years; cause of death, typhoid.

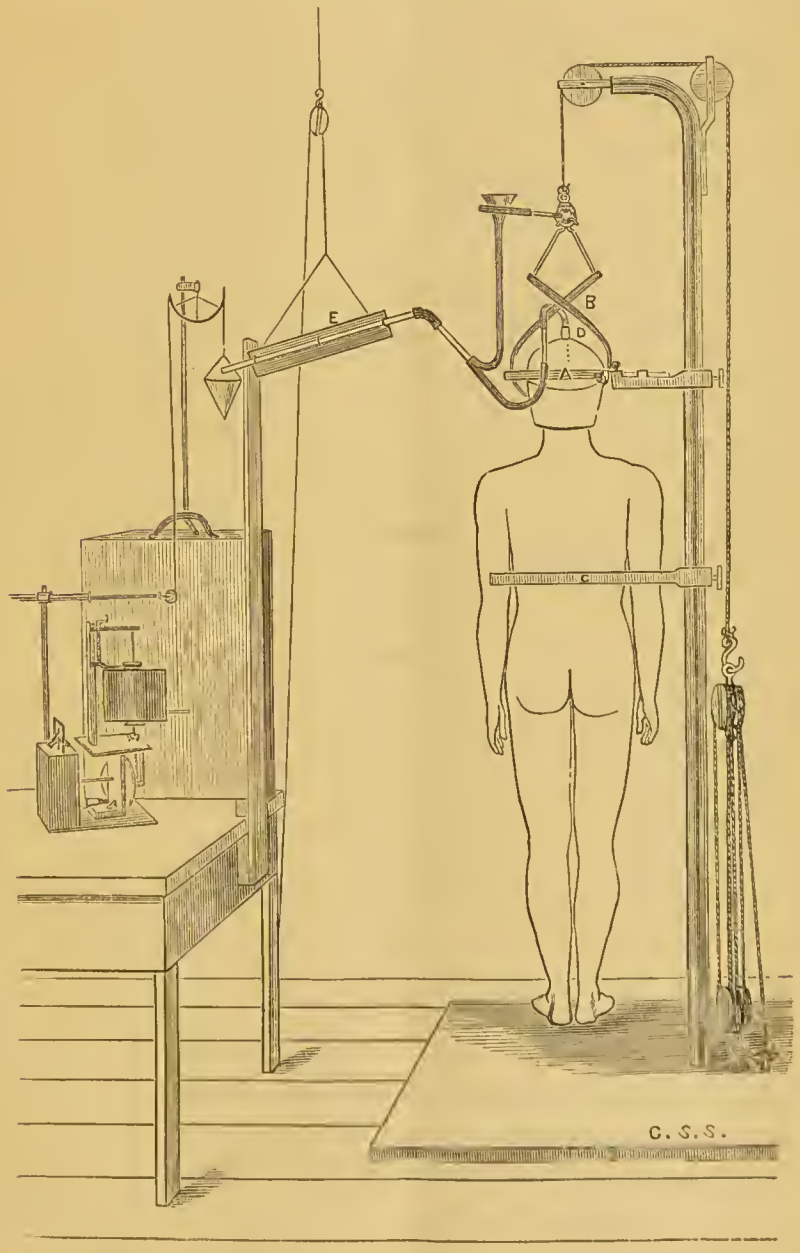
Body hanging freely from the head:—Raising the trunk by the pelvis caused the ejection of 190 cubic millimetres; bending the body backwards caused the ejection of 1,025 cubic millimetres; bending the body forwards caused the ejection of 600 cubic millimetres; rotation by the shoulders to right or left caused ejection of 100 cubic millimetres.

Body hanging as before, but with cervical region of spine fixed against the bar:—Bending the body backwards gave ejection of 450 cubic millimetres; bending the body forwards gave ejection of 150 cubic millimetres; bending trunk backward through 40° over a fulcrum two inches below inferior angle of scapula gave ejection of 2,400 cubic millimetres; bending trunk forward through 45° over fulcrum at similar level gave ejection of 28 cubic millimetres.

V. *November* 16, 1889.—Cadaver, male, powerful frame, æt. thirty-six years, weight 11st. 2lbs.; cause of death, pneumonia.

Body hanging freely from the head:—Raising the trunk by the pelvis caused the ejection of 70 cubic millimetres;

TO ILLUSTRATE PAPER ON THE EFFECT OF MOVEMENTS OF THE HUMAN BODY ON THE SIZE OF THE SPINAL CANAL.



bending the body backwards caused the ejection of 1,800 cubic millimetres; bending the body forwards caused the ejection of 920 cubic millimetres; rotating the shoulders to right or left caused ejection of 100 cubic millimetres.

Body hanging as before, but with the cervical spine fixed against the bar:—Bending the body backwards caused ejection of 800 cubic millimetres; bending the body forwards caused ejection of 260 cubic millimetres; bending trunk backwards through 40° over fulcrum two inches below inferior angles of scapula gave ejection of 1,250 cubic millimetres; bending forward through 45° over fulcrum at same height gave ejection of 30 cubic millimetres.

VI. *November* 15, 1889.—Cadaver, male, weighing 12st. 4 lbs. Cause of death, cardiac disease.

Body hanging freely from the head:—Raising the trunk by the pelvis caused ejection of 48 cubic millimetres; bending the body backwards caused ejection of 1,200 cubic millimetres; bending the body forwards caused ejection of 250 cubic millimetres; rotation by shoulders to right or left caused ejection of 140 cubic millimetres.

Body hanging as before, but with cervical spine fixed against the bar:—Bending the body backwards gave ejection of 900 cubic millimetres; bending the body forwards gave ejection of 200 cubic millimetres; bending body backwards through 40° over fulcrum two inches below inferior angle of scapula, gave ejection of 2,300 cubic millimetres; bending body forward through 45° over fulcrum at similar level gave ejection of 36 cubic millimetres.

VII. *October* 22, 1889.—Cadaver, female; weight, 7 stone 10 lbs.; æt. fifty-four years. Trauma.

Body hanging freely from the head:—Raising the trunk gave ejection of 90 cubic millimetres bending the body backwards caused ejection of 280 cubic millimetres; bending the body forwards caused ejection of 145 cubic millimetres; rotating the shoulders to right or left gave ejection of 95 cubic millimetres.

Body hanging as before but with cervical region fixed against bar:—Bending body backward gave ejection of 170 cubic millimetres; bending body forward gave ejection of

40 cubic millimetres; bending trunk backward through 40° over fulcrum at inferior angle of scapula gave ejection of 1,100 cubic millimetres; bending forwards through 45° over similar fulcrum gave ejection of 32 cubic millimetres.

QUANTITY OF FLUID DISPLACED FROM CRANIO-VERTEBRAL CANAL DURING MOVEMENTS OF THE BODY.

I.—Cadaver Hanging Freely from the Head.

Age in Years.	Sex.	Relieving the spine from the weight of the body by lifting.	Bending Body.		Rotation by the shoulders.
			Backward.	Forward.	
		Cub. Mil.	Cub. Mil.	Cub. Mil.	Cub. Mil.
4	♂	263	1500	258	78
7	♂	450	530	215	180
28	♀	98	480	220	110
30	♂	190	1,025	600	100
36	♂	70	1,800	920	100
45	♂	48	1,200	250	140
54	♀	90	280	145	95

II.—Cadaver Suspended from Head, but with Cervical Region of the Spine Prevented from Bending by a Bar.

Age in Years.	Sex.	Bending Backward.	Bending Forward.	Bending of spinal column over a bar at level close below the inferior angle of the scapula.	
				Backward.	Forward.
		Cub. Mil.	Cub. Mil.	Cub. Mil.	Cub. Mil.
7	♂	215	180	—	—
28	♀	230	200	2,050	20
30	♂	450	150	2,400	28
36	♂	800	260	1,250	30
45	♂	900	200	2,300	36
54	♀	170	40	1,100	32

Conclusions that we arrive at from our observations may be shortly set forth as follows :—

1. That when the body hangs freely and vertically from the skull the capacity of the cranio-vertebral canal is at a maximum.

2. That with the body in the above position, when the weight of the trunk and limbs is taken off by, for instance, lifting and supporting the body vertically, there is a diminution in the capacity of the cranio-vertebral canal, but the diminution is a very slight one.

3. That when the vertebral column is bent backward or forward, especially in the former direction, there is a not inconsiderable diminution in the capacity of the cranio-vertebral canal as compared with its capacity when the body is hanging freely and vertically.

4. That the alterations in the curvatures of the spinal canal by various movements of the body do influence the capacity of that canal, but not to any great extent; much more however in the child than in the adult.

A point of practical interest may be adverted to. From the above measurements it would appear that by suspension the size of the spinal canal is increased in the adult of middle age to the extent of some 100 cubic millimetres. Estimating the total capacity of the canal at 102 ccm., this measurement means an increase in the size of the canal to the extent of 1-1020·0th of the whole canal. This increase is so small that it becomes difficult to conceive how, in the "suspension" treatment lately introduced for cases of tabes dorsalis, &c., there can, as has been sometimes claimed, be any actual stretching of the spinal cord.